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BRAZILIAN AUTOMOTIVE INDUSTRY IN THE NINETIES

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ABSTRACT

This paper aims to carry out an analysis of fuzzy clusters in the Brazilian automotive industry to contribute to the analysis of the relative importance of these economic activities in the national productive structure and in their regional contexts. The intention is to assess whether, once they have been established in the structure of a determined region, the economic activities of the industry establish productive relationships similar to other industries to the point of leading an industrial group in the regions or in the national economy.

INTRODUCTION

In the nineties, the automotive industry stood out in the international scene due to investments made in emerging markets such as India, China and Brazil. In the case of Brazil in particular, the macroeconomic and political ambient that was aimed towards modernization and increased capacity for production and greater economic integration of the industry in Mercosur, became extra stimuli for new investments in the sector.

With the *Regime Automotivo* (system of tax benefits for car manufacturers) that was set up in 1995, the automobile manufacturers benefited from special import tariffs for products from other Mercosur countries. From that period onward, state governments that hoped to capture future investments in the industry, broadened incentives. The result was a fiscal war in the Brazilian economy in the late nineteen nineties.

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The adoption of these incentives by the Brazilian government to encourage development of the automobile industry and stimulate a much needed debate on the efficiency of recent public policies, raised questions concerning the relative importance of this industry in the development of regional economies and their role in the national productive structure.

In economic theory, the input-output analysis has been widely explored in studies that intend to identify and analyze the productive profile of different economies. Within the analyses derived from the application of this model, we may highlight the analyses that concentrate on the behavior of block industries, identifying clusters or groupings of industries according to the similarity of their goods and services.

This paper aims to carry out an analysis of fuzzy clusters in the Brazilian automotive industry to contribute to the analysis of the relative importance of these economic activities in the national productive structure and in their regional contexts. The intention is to assess whether, once they have been established in the structure of a determined region, the economic activities of the industry establish productive relationships similar to other industries to the point of leading an industrial group in the regions or in the national economy.

2. LITERATURE REVIEW

2.2 The automotive industry in Brazil

2.2.1 The role of the state: from implantation to the recent phases of consolidation and modernization

The active role of the state was decisive for the development of the Brazilian automobile industry, both at the early stages and consolidation, in the fifties and sixties, and more recently in the phases of modernization and expansion to other regions in the nineties. Even with the first assembly line of vehicles established in Brazil in 1919, the initial efforts to set up the automobile industry in Brazil were not made until the nineteen fifties during the Getúlio Vargas administration with the strengthening of the steel industry and the creation of the National Steel Company and other important industries (Ferro, 1992)

In the late fifties, there was an effective commitment on the part of the government to develop the sector as a result of the policy of then president Juscelino Kubitschek. His policy program, called the Plan of Goals, covered five areas: energy, transport, supply of foodstuff, education and base industry. The Plan of Goals included a specific development program for the automobile industry, organized by the mediation of the National Bank for Economic and Social Development (BNDES), which eased restrictions on the import of equipment, raw materials and components for a certain period of time (Baer, 1995; Orenstein & Sochaczewski, 1990).

This program was run by the Executive Group of the Automobile Industry (GEIA). According to Santos & Burity (2002), within the responsibilities of the GEIA were the definition of rules of installation, production targets and plans to nationalize the industry, with a priority for the production of cargo vehicles and attenuating the deterioration of the balance of payments resulting from increased imports of cars and spare parts. As a result, at the end of the Kubstischek administration, around half of car production consisted of passenger vehicles and the rest was made up of utility vehicles and trucks (Baer, 1995).

According to Santos & Burity (2002), the concession of quotas for the import of spare parts that were not produced in the country, the exchange rate favored importing equipment and tax exemptions for the importation of components for automobiles, were some of the exchange rate and fiscal incentives adopted by the government at this time.

In the seventies, the BNDES was responsible for the financial support and numerous restructuring programs for industries without access to affordable and more long-term credit by way of specific programs, one of them for the spare automobile parts industry. The National Development Plan (II PND) also deserves to be mentioned. Nevertheless, after the petroleum crises and the II PND, divergences arose between the public and private sectors (Bedê, 1997).

In the early nineties, the state became involved in making policies to strengthen the industry once again. As highlighted by Bonelli & Veiga (2003), in no other industry "was incentive so extensive and industrial policy so explicit" during this time.

Policies were adopted from the start of the decade, as shown in Table 1 below.

Table 1: Policies for the automobile industry from 1990-1995

Government	Policies/Measures
Fernando Collor (1990-1992)	Program of tariff reductions (80% a 35%) from 1990 to 1994. Financial incentives suspended, non-tariff barriers eliminated. Fiscal incentives (reduction of industrialized products tax) for small cars. Mercosur initiative with Argentina, Paraguay and Uruguay. 1992: Industrial Arbitration Process. Targets set for prices, production and export, jobs and salaries negotiated with industry, suppliers, trade unions and government. Reduction of taxes (industrialized product tax and ICMS) enforced to increase demand
Itamar Franco (1993-1994)	February, 1993: Arbitration process of the industry is renegotiated. New goals are established. April, 1993: fiscal incentives are given to cars in the lower price range; industrial product tax falls to 0.1%, ICMS is reduced and exceptions are made for COFINS. October, 1994: Government lowers tariffs to 20% (which was the goal only for 2001)

Fernando Henrique Cardoso (1994-2002)	February, 1995: new meeting for industrial arbitration process (tariffs again increased to 32%, industrialized product tax for low price cars is raised to 8%) March, 1995: tariffs raised to 70% June, 1995: New policy established by the government (import quotas, reduction of tariffs to 2% for equipment and components associated with exporters, incentives for investments are given – accelerated depreciation). Import of cars from Argentina is exception to the new measures.

Source: Laplane & Sarti (1997)

With a view to restarting investments and the promotion of exports via increased competitiveness, the Brazilian government adopted the *Regime Automotivo* in 1995. The program established increased protection for the industry and was reformulated in 1997 to involved less developed states. Besides a fiscal incentive package for companies to set up in Brazilian states as a whole, there were added incentives for plants to be opened in the Northern, North-eastern and Central-Western states (Bonelli & Veiga, 2003; Laplane & Sarti, 1997; Santos & Burity, 2002).

According to Santos & Burity (2002), the plan allowed a reduction of 50% on import tax for vehicles for companies that were already producing or involved in producing in the country. Furthermore, there were drastic tax reductions on the import of industrial goods, tools and molds for raw materials. The results of the tax cut were seen in the spare parts industry, affecting its prices. Besides the import tariffs, the IPI (tax on industrialized products) for industrial goods, raw materials, spare parts, pneumatics and packaging material were also reduced.

In the case of previously established companies, average nationalization indices of 60% were required. For new companies, this index was 50%, as well as a compensation system for imports and exports. In 1995, at which time the import tax rate was 70%, with the *Regime Automotivo* program, the same taxes were set at 35%.

A special trade agreement between Brazil and Argentina established the Brazil-Argentina Automotive Agreement of 1995. The difficulties of commercial relations between the two countries, however, were made clear with the devaluation of the real against the peso in January, 1999. From 2000, a common policy was established between the two countries for the industry to be in force from 2000 to 2005 (Bonelli & Veiga, 2003; Bonelli, 2001).

The concession of incentives, however, was not restricted to the federal government. Among the policies of the states to attract new investments, Santos & Burity (2002) and Bonelli (2001) have witnessed the use of measures that vary from the use of direct expenditure with financing and participation of capital, to support in supplying infrastructure and the process of simplifying bureaucracy. The most widely criticized measures, however, are those which compromise the revenue of the ICMS (Tax on the Circulation of Goods), the main source of income for state governments. It is these last measures that justify the term fiscal war used to characterize the behavior of the governments of several states during this period.

The widespread use of tax reductions and exemptions[5] from the ICMS tax was accompanied by a variety of other measures. In the case of Rio de Janeiro, the new units of Volkswagen were given a five-year tax deferral for 75% of their ICMS tax, benefits of infrastructure and had natural gas, digital telephones, water and electric energy at their disposal. These were practically the same benefits offered for the installation of the bus and truck factory in Resende. The donation of industrial plots of land was the measure adopted by the government of the state of Paraná to entice Renault to open their factory in the state.

The effects of the fiscal war, however, have been a matter of debate in literature. According to Perobelli & Piancastelli (1996), the fiscal war is simply a fiscal renunciation and is harmless. The authors argue that the adoption of a similar set of instruments by states reinforces the question of location as a decisive factor in the flow of investments. Bonelli (2001) suggests that the real beneficiaries of the reduction of the ICMS tax are the multinational companies who assemble cars. According to this author, companies were given an opportunity to set up their plants at an extremely low cost and that they would have set up in Brazil anyway even without all these benefits.

The author argues that the states may be the losers here since, at the time of his study, there were no papers to estimate the cost-benefit relationship for regions that had given these tax incentives, simultaneously assessing the impact on the creation of jobs and income[6]; and the cost resulting from the loss of revenue and the expenditure with infrastructure, electricity, water and sanitation, donation of land etc.

Arbix & Rodrigues-Pose (2001) agree with the former viewpoint by defending that territorial competition was nothing more than high expenditure. In the view of these authors, any well-being that the industry stimulates is neutralized by the direct and indirect costs of attracting investments. From a global stance, this territorial competition implies closing other plants and, therefore, leads to the reduction of economic activity and increased unemployment nationwide.

The set of policies in favor of the automobile industry in the nineties led to the effective widening of production capacity and modernization of industry. The efforts of this restructuring were seen, especially in production levels, jobs and foreign trade, which we will examine more closely in the next section.

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[5] Deferral of ICMS tax means exemption for the first agent in the productive chain, allowing for the sale of cheaper products. The next agent, even having to pay it in full, has a financial gain, as the ICMS is a tax payable on the value added to the product (Bonelli, 2001).

[6] For a discussion on this topic, see **Cavalcanti & Udenrman in this volume.**

2.2.2 The panorama of the nineties in the Brazilian automotive industry

From 1990 to 1993, the production of autovehicles – cars, light commercials, trucks and buses – doubled in the Brazilian economy, rising from 914,000 to 1,800,000 units. This growth was sharper in the production of passenger vehicles, the volume of which rose from 663,000 units in 1990 to 1,500,000 in 2003.

This growth mostly took place from 1990 to 1997, with a sharp retraction in 1998/1999, picking up again in 2000. This retraction is linked to the slowing of the internal market, and the larger part of production is destined for domestic consumption[7].

Increased production reflects in part the modernization and increased capacity for production in this sector of Brazilian industry. Besides the reflections in production, the outcome of modernization in the industry has been less use of labor. In 1990, the production of autovehicles provided 117,396 jobs in Brazil. In 2002, that number had fallen to 81,737, in other words, only 70% of those registered, according to the data presented in Figure 1.

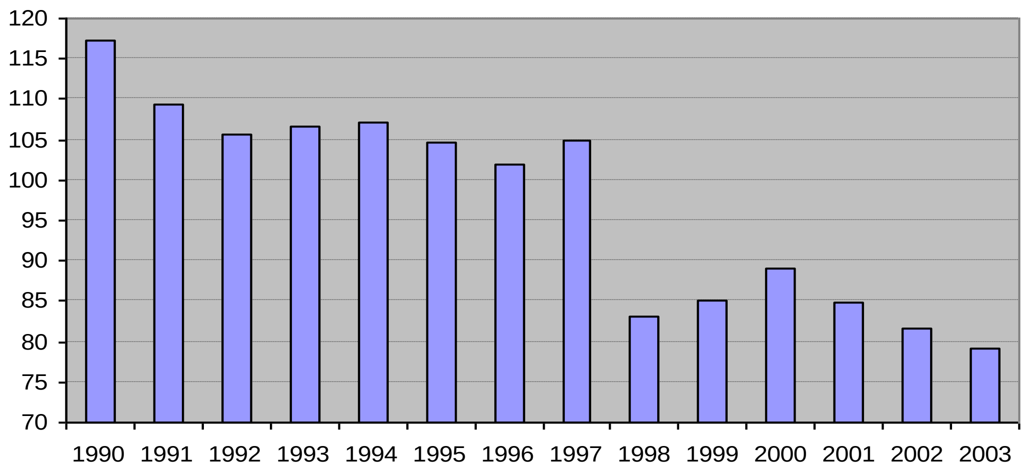

Figure 1 – Employment in the production of autovehicles. Brazil 1990-2002 (in thousands of people)

Source: Anfavea (2004)

The reduction in the number of people employed is largely a result of automation and robotization of some plants during this period. The industry has also undergone intense internal restructuring for production[8].

[7] In 2003, around 71% of autovehicle production was destined for the domestic market (Anfavea, 2004)

[8] for further details on the internal restructuring of the companies with a view to establishing more suitable standards of efficiency with lean production methods, see Salerno (2002)

According to the estimates given by Anfavea (2004), in 2003, the automobile industry comprised a total of 48 plants, in seven states and 27 cities and towns. Of these 48 plants, around 22 were inaugurated from 1996 to 2002. With capacity to produce 3.2 million vehicles per year, this industry accounted for around R$10 billion in direct taxes and R$1.5 billion in indirect taxes. According to Anfavea, the automobile industry, including agricultural machinery and automotives, is responsible for creating 92,000 direct jobs and in that year established inter-industrial relations with over 200,000 companies and 3,700 showrooms. Its GDP, including the spare parts industry, accounts for around 13.5% of industrial GDP in Brazil and 4.5% of the GDP on the whole.

According to what has been seen in the production of autovehicles, the spare parts industry grew until 1997. In the following years, the volume of sales in the industry cooled. Exports grew by 82% from 1990 to 1992. on the other hand, the installation of new foreign companies in Brazil and the global strategies adopted by these companies led to a significant increase in the imported volume of the sector. Thus, the volume of imports that was US$837,000,000 in 1990, had increased around five times by 2002, reaching US$3.9 billion.

When it comes to the investments made in the sector during this period, the volume grew until the late nineties, especially from 1995 to 1998. in the next section, some aspects of the investments in this industry in the nineties are highlighted, as well as their reflections on regional configurations.

2.2.3 Investments and recent regional configuration

In the nineties, worldwide companies announced investments in the Brazilian economy with a view to establishing new plants or restructure the old ones. Companies such as Fiat, Ford, General Motors and Volkswagen increased their presence on the domestic market, while others such as Mercedes and Renault set up new plants. The huge investments in this industry in the nineties are similar to those seen during the initial period of their installation (Arbix & Rodrigues-Pose, 2001).

Indeed, the investments made in the automobile industry were expressive. The amount exclusively put into the production of autovehicles from 1990 to 1992 was over US$18 billion, with 80% of this total made after 1993 (Anfavea, 2004). The regional guidance of these investments, however, varied a great deal. According to data from Anfavea (2004) and from Santos & Pinhão (1999), it is possible to systematize them by region, as shown in Table 2.

Several reasons are mentioned to explain the regional deconcentration of this industry and the degree of importance attributed to each of them differs throughout the literature. Arbix & Rodrigues-Pose (2001) highlight that in the past, there was qualified labor and superior infrastructure in the South-east and that led to greater development in this region. More recently, the relatively lower cost of labor in the other regions of the country and improvement in the quality of skilled labor have led to deconcentration. When it comes to salaries, there is certainly better organization of trade unions in the South-east with greater bargaining power in the industrial ABC region of São Paulo. In the city of São Paulo, there are also the effects of pollution and traffic congestion.

Therefore, the Brazilian automobile industry, which has always historically been concentrated in São Paulo state and the South-eastern region of the country, has recently shown signs of deconcentration to other parts of the country. Table 3 below shows the current regional configuration of the main companies in this industry

Table 2. Regional distribution of direct foreign investment in automobile assembly plants in Brazil 1996-2001

Location	Company	Country of Origin	Date of investment	Minimum planned investment (in millions of US$)	Planned annual capacity (in thousands)
São Paulo					
São Bernardo do Campo	BMW/ L.Rover	UK	1998	150	150
São Carlos	Volkswagen	Germany	In operation	250	300*
Indaiatuba	Toyota	Japan	1999	150	15
Sumaré	Honda	Japan	In operation	100	30
Paraná					
São José dos Pinhais	Renault	France	1999	750	100/110
São José dos Pinhais	Audi	Germany	1999	600	120
Campo Largo	Chrysler/ BMW	USA/Germany	1999	600	120
Minas Gerais					
Juiz de Fora	Mercedes	Germany	1999	820	70
Betim	Fiat	Italy	1998	500	5.000*
Sete Lagoas	Iveco	Italy	1998	250	20
Belo Horizonte	Fiat	Italy	1999	200	100
Rio Grande do Sul					
Gravataí	GM	USA	1999	600	120
Caxias do Sul	Navistar	USA	1998	50	5
Rio de Janeiro					
Porto Real	PSA-Peugeot	France	2000	600	1.000
Resende	Volkswagen	Germany	In operation	250	50
Bahia					
Camaçari	Ford	USA	2001	1300	250

Source: Anfavea (2004), Santos & Pinhão (1999) [9]

[9] The Ford project, initially set up in Guaíba, Rio Grande de Sul, expected investments of half a million dollars and a capacity for 100,000 units of vehicles (Cavalcante & Uderman, 2003). Other investments such as those announced by Mitsubish, Ásia and Hyundai were not made owing to the Asian crisis.

Table 3. Regional Distribution of Brazilian Automobile Industry

Region	State	City/Town	Main Companies	Products
North	Amazonas	Manaus	Cross Lander	Motorcycles
			Pólos de duas Rodas	
			Agrale	Assembly of motorcycles and scooters
Northeast	Ceará	Catole Horizonte	Troller	
	Bahia	Camaçari	Ford	Cars
Southeast	Minas Gerais	Betim	Fiat Automóveis	Cars, light commercials, engines
		Sete Lagoas	Iveco	Light commercials, trucks and buses (Iveco)
			Iveco-Fiat	Light commercials and trucks (Fiat)
		Juiz de For a	DaimlerChrysler	Cars
	Rio de Janeiro	Duque de Caxias	Óbvio	
		Porto Real	Citroën	Cars, light commercials, trucks,
			Peugeot	Engines.
		Resende	VW Caminhões	Trucks and buss chassis.
	São Paulo	Indaiatuba	Toytota	Cars
		São Bernardo do Campo	DaimlerChrysler	Trucks, buses and assemblages
			Ford	Cars, light commercials, trucks
			Karmann-Ghia	Tool room, devices, stamping sets, bodies, aria, sets and subsets, prototypes, assembly of vehicles
				Light commercials
			Land Rover	Trucks, buses, industrial and maritime engines.
			Scania	
				Car parts
			Toyota	Cars, light commercials
			Volkswagen	
		São Jose dos Campos	General Motors	Cars, light commercials, foundry, CKD preparation for export, engines and transmissions.
		São Caetano do Sul	General Motors	Cars
		Sumaré	Honda	Cars
		Taubaté	Volkwagen	Cars
South	Paraná	São Jose dos Pinhais	Audi/Volkswagen	Cars, light commercials,
			Nissan	Light commercials
			Renault	Cars, engines, light commercials
		Curitiba	Volvo	Trucks, truck cabins, buses and engines
		Caxias do Sul	Agrale	Trucks, buses
			International	Truck assembly
		Gravataí	General Motors	Cars
Central-West	Goiás	Catalão	Mitsubishi	Light commercials

Source: Automotivebusiness (2004); Anfavea (2004)

Even with the recent regional deconcentration moves, the volume of production in the state of São Paulo is still higher than the other states. According to Anfavea (2004), around 53.4% of Brazilian car production is done in this state. Minas Gerais, Paraná and Bahia are next in line with 20.1%, 7.6% and 7.5% respectively in volume of production.

3 METHODOLOGY[10]

3.1 Input-Output Model

This paper is based on the input-output model developed by Wassily Leonteif. The model relates the information of flows of input and output for each of the sectors of an economic region during a determined period of time (Feijó et al., 2001; Leontief, 1986).

In mathematical terms, the relationship between sectors may be represented by a system of linear equations in the form of a matrix so that each of the equations describes within the economy the distribution of a product from a certain industry or sector. The economic interpretations to be had from the use of the model come from the resolution of this system of equations by way of an inverse matrix and other algebraic derivations of the model (Miller & Blair, 1985).

According to Miller & Blair (1985), the fundamental aspect of the model can be expressed by the equation:

$$X = (I - A)^{-1} Y \tag{1}$$

in which,

$(I - A)^{-1}$ represents the Leontief inverse matrix.

X represents the production vector;

Y represents the final demand vector;

[10] For a detailed discussion about the data base, inter-regional matrix see Cecchini (2005).

A represents the matrix of technical coefficients of the sectors;

Equation (1), by multiplying the final demand vector Y by the Leontief inverse matrix, allows us to measure the total impacts caused by exogenous shocks resulting from the variations of the final demand components (consumption by families, exports and private investment).

The inter-regional input-output models are more suitable when the intention is to analyze the interactions between economic regions. According to Miller & Blair (1985), an inter-regional model for two regions L and M, can have its coefficients matrix represented in matricial terms as:

$$A = \begin{bmatrix} A^{LL} & A^{LM} \\ A^{ML} & A^{MM} \end{bmatrix} \qquad (2)$$

The vectors X^L and X^M will constitute the total production vector, X

$$X = \begin{bmatrix} X^L \\ X^M \end{bmatrix} \qquad (3)$$

The final demand vector, Y will be composed of the vectors Y^L and Y^M

$$Y = \begin{bmatrix} Y^L \\ Y^M \end{bmatrix} \qquad (4)$$

The complete inter-regional model can be represented as:

$$(I - A)X = Y \qquad (5)$$

$$\left(I - A^{LL}\right)X^{LL} - A^{LM} X^{M} = Y^{L} \qquad (6)$$

$$- A^{ML} X^{L} + \left(I - A^{MM}\right)X^{M} = Y^{M} \qquad (7)$$

Considering in equation (7) the variation of final demand of region M to be null, i.e.,

Y^M =0, we have:

$$X^M = (I - A^{MM})^{-1} A^{ML} X^L$$

$$(I - A^{LL}) X^L - A^{LM} (I - A^{MM})^{-1} A^{ML} X^L = Y^L$$

(8)

(9)

Comparing equation (9) with the equation $(I - A^{LL})^{-1} X^L = Y^L$, which would be equivalent to a model from a single region, we can see in equation (9) the following additional term:

$$A^{LM} (I - A^{MM})^{-1} A^{ML} X^L \qquad (10)$$

The above equation represents the regional feedback effect.

3.2 Fuzzy clusters[11]

One of the more relevant contributions in literature concerning the methods for identifying clusters based on the input-output theory can be found in Czamanski & Ablas (1979). These authors discuss and analyze fourteen studies that seek to identify clusters and industrial complexes. Other works also deserve to be mentioned, such as Streit (1969), Bergsman et al (1972, 1975), Roepke et al (1974), Blin & Cohen (1977), Bergman (1997) and Hewings et al.(1998), Oosterhaven et al. (1999) and Hoen (2002).

[11] For a detailed discussion on this topic see Cecchini (2005)

One aspect in which the method used in this paper differs from most of the methods used in literature is the type of cluster identified. Most methods allow for the identification of clusters formed by a limited number of sectors, identifying crisp clusters. In these analyses, the sectors belong to only one cluster and it is not possible to allow participation in more than one cluster at a time, which leads to analyses that are far from economic reality.

To this end, Czamanski (1974) utilizes four different coefficients in one of the first attempts to evaluate clusters according to the most important sectors. More recently, Dridi & Hewings (2002) utilize the analysis of fuzzy clusters, seeking to take into consideration the complexity of the productive relationships in the establishment of sector groupings. The method does not require the researcher to choose arbitrarily the values of restrictions required by other methods. It is fundamental to add that the groupings are identified in such a way that all sectors of the economy belong to a certain cluster in varying degrees. These characteristics were preponderant in the choice of method used in this paper, which will be dealt with in further detail later.

The sector groupings, or clusters as they are called in this paper, do not restrict their relationships for the purchase and sale of inputs to a small number of activities in the productive structure, even when there is great similarity between them. On the contrary, the sectors establish input purchase and sale relationships with a high number of sectors. In other words, it is possible that some activities, when grouped together according to the input purchase and sale relationships, belong to more than one cluster at a time.

Utilizing the fuzzy set theory, it is possible to carry out an analysis that takes this fluidity of the productive structure into consideration. Dridi & Hewings (2002a) present the utilization of the analysis of fuzzy clusters resulting from this theory as a methodological proposal for assessing sector clusters and do an exercise with the matrix of the American economy. By recognizing the limitations of the traditional crisp approach, the fuzzy approach aims to analyze the complexity of the productive structure more coherently.

An application of this method in a study of the Brazilian economy can be found in Simões (2003). The author utilizes the fuzzy cluster approach to identify spatial industrial complexes in the state of Minas Gerais, applying the method in a way that is similar to its use in this study. This paper, by utilizing the use matrix data, requires a decomposition of that matrix in order to obtain distances between sectors. This method, called dual scaling, will be outlined in item 3.2.2 of the following section, which seeks to specify the methodology utilized.

3.2.1 **Identification of fuzzy clusters**

The method for identifying fuzzy clusters is described below, as demonstrated by Dridi & Hewings (2002a).

Considering *X* as a finite set of points, and a generic point, *x*, a fuzzy subset of *X*, denominated *A*, will be characterized by a function of membership, $\mu_A(x)$ that will associate, at each *x* point, a coefficient within a real interval of [0.1].

Thus, the subset, *fuzzy A* is a set of ordered pairs $\{(x|\mu_A(x)); \forall x \in X\}$, in which $\mu_A(x)$ is the membership coefficient of the *x* element in *A.*

If we let $A_{k,,}$ $\forall k = 1, ...K$, all the subsets of a universal set *X*, have the following properties:

$$\mu_{A_k}(x) \in [0,1]; \forall x \in X, \forall k = 1,..K$$

$$\sum_{k=1}^{K} \mu_{A_k}(x) = 1 \qquad (11)$$

The authors mention controversies concerning the format of the membership function, especially because this type of function is determined *ad hoc*, and adopt the proposal of Kaufman & Rosseeuw (1990). According to this alternative, the clusters are obtained minimizing the following objective function:

$$\min_{\mu_{ik}} \sum_{v=1}^{K} \frac{\sum_{i,i'}^{r} \mu^2{}_{iv} \mu^2{}_{i'v} d_{i,i'}}{2\sum \mu^2{}_{i'v}}$$

(12)

restricted to:

$$\mu_{iv} \geq 0; \forall i = 1,\ldots,r; \forall v = 1,\ldots,k$$

$$\sum_{v=1}^{k} \mu_{iv} = 1; \forall i = 1,\ldots,r$$

In which:

μ_{iv} represents the values of the membership coefficients of each of the *i* sectors in relation to the *v* clusters, which will minimize the function;

$d_{i,i'}$ represents the Euclidian distance calculated between the sectors of the matrix submitted to the cluster analysis, defined in the following section.

To the authors, this method has advantages over the other models of fuzzy cluster analysis. This is because this method minimizes errors by utilizing a unitary distance exponent whereas in other methods, the distance is squared.

The fanny algorithm classifies *r* objects (in this case sectors) into *k* clusters based on the observation of *s* characteristics, or observations of a variable. Obtaining the *s* characteristics requires a decomposition of the use matrix by using a dual scaling technique which will be demonstrated below.

3.2.2 Dual scaling

The dual scaling method is a descriptive, multivaried analysis technique introduced by Nishisato (1994). Its application in the input-output matrix allows for the decomposition of the complexity of associations that are established between the sectors of the productive structure.

According to Dridi & Hewings (2002a)[12], the technique applied to a contingency table, in this case an input-output table, allows us to determine a vector of rows weight and a vector of columns weight that maximize the relationship:

$$\eta^2 = \frac{SS_b}{SS_i} \qquad (13)$$

Being:

$\mathbf{F} = [f_{i,j}]_{(r+1) \times (c+1)}$; flow matrix in the input-output table.

$\mathbf{f}_r$: vector of total output of the input-output table.

$\mathbf{f}_c$: vector of total input of the input-output table.

$\mathbf{D}_r$: diagonal matrix with row total in the main diagonal;

$\mathbf{D}_c$: diagonal matrix with columns total in the main diagonal;

y: a vector of weights for the supplying sectors;

x: a vector of weights for the demanding sectors;

f_t : the total value or intensity of the input-output table.

Where,

SS_b expresses the variation between the **F** rows, and SS_t expresses the total variation in the whole input-output table.

[12] The description of the technique is based on Dridi & Hewings (2002a)

Thus,

$$SS_b = \mathbf{x'F'D_r^{-1}Fx},$$

$$SS_t = \mathbf{x'D}_c\mathbf{x}$$

The problem of maximization can be solved by setting SS_t and maximizing SS_b, in which the Lagrangian will be solved by:

$$L(\mathbf{x}, \lambda) = \mathbf{x'F'D_r^{-1}Fx} - \lambda(\mathbf{x'D_c x} - f_t) \tag{14}$$

With the first order conditions:

$$\frac{\partial L}{\partial \mathbf{x}} = \mathbf{F'D_r^{-1}Fx} - \lambda \mathbf{D_c x} = 0$$

$$\frac{\partial L}{\partial \lambda} = \mathbf{x'D_c x} - f_t = 0$$

By pre-multiplying by **x**' and organizing the terms, equation (14) can be rewritten thus:

$$(\mathbf{F'D_r^{-1}F} - \eta^2 \mathbf{D_c})\mathbf{x} = 0, \tag{15}$$

Which, pre-multiplied by $\mathbf{D_c^{-1}}$, gives us the following eigenequation:

$$(\mathbf{D_c F'D_r^{-1}F} - \eta^2 \mathbf{I})\mathbf{x} = 0, \tag{16}$$

Once a solution of η^2 has been established, a eigenvector ***x***, associated to the highest value of η^2 is found in equation (16). The eigenvector **y** is found utilizing the dual relation:

$$y = \left(\frac{1}{\eta}\right)\mathbf{D}_{\mathbf{r}}^{-1}\mathbf{Fx}$$

(17)

Thus, the first solution can be obtained, in other words, the first vectors of weights *x* and *y* of the new resulted matrix. If the first solution is insufficient to explain the correlation between rows and columns, new solutions are found, generating other vectors of weights *x* and *y*. In this case, all the possible *s* solutions are found.

The application of this technique in the input-output table allows us to obtain two matrixes: one which establishes *s* weights for the columns of dimensions *c* versus *s*, in which c is the number of columns in the original matrix. The second matrix establishes *s* weights for the rows and their dimension will be *r* versus *s* and *r* is the number of rows in the original matrix.

Therefore, the resulting matrixes are utilized to calculate the Euclidean distance between the rows and columns. The next step consists of the realization of the cluster analysis based on the distances calculated from the pondered matrixes. The number of clusters analyzed must be the highest possible (Simões, 2003). For this work, S-PLUS software was used, whose fuzzy cluster analysis is obtained by the fanny algorithm and allows for a maximum number of clusters, so that $k = \frac{s}{2} - 1$, where *s* is the number of solutions found, as described in the dual scaling procedure.

Thus, the result of the cluster analysis consists of a matrix formed by vectors expressing the membership coefficients of each of the sectors that form the clusters identified in the economy. These matrixes are called membership matrixes.

The membership information subsidizes a preliminary analysis of the productive clusters. Other measures, like those given below, can be employed to characterize better the importance of the sectors in each of the clusters identified.

3.2.3 Involvement of the Sectors

According to Dridi & Hewings (2002b), the relative importance of a cluster can be obtained through the coefficient called involvement, defined as:

$$Inv_A(x_i) = \frac{\mu_A(x_i)}{card(A)}; \forall i = 1,...,n; \qquad (18)$$

Where,

$\mu_{A_A}(x_i)$ represents the membership coefficient of the sector to the cluster

$card(A_k) = \sum \mu_{A_A}(x_i); \forall k \in C$, represents the cardinality of the sectors,

X is a set of points, in this case, sectors, x_i finite and countable,

$\forall i \in I = \{1,...,N\}$,

A_k are the fuzzy X sets.

$\forall k \in C = \{1,...,K\}$.

Thus, the highest values of this involvement coefficient indicate the most important sectors of the cluster, with leadership of the cluster in question. In their turn, the lower values indicate the sectors with secondary importance in the cluster, in other words, the sectors that supply support to the main activity of the cluster.

3.2.4 Subsethood

This is an indicator for assessing how much a fuzzy set is present in another fuzzy set. It is defined as:

$$D(B,A) = \frac{card(B \cap A)}{card(B)} = \frac{\sum_i \min(\mu_A(x_i), \mu_B(x_i))}{\sum_i (\mu_B(x_i))} \qquad (19)$$

Therefore, *D (B,A)* expresses the subsethood of cluster A in relation to cluster B. The subsethood matrix expresses the mutual dependence of the clusters in the productive structure.

4 RESULTS & DISCUSSION

The clusters identified in this paper are called fuzzy clusters because the participation of all economic activities in a productive grouping are considered. The most important activities in a cluster are called leader activities, and the others are called support activities to the production of the final goods of the cluster.

The first step in the identification of clusters consists of decomposing the use matrix into a similarity matrix using the dual scaling method. This procedure results in two similarity matrixes: one referring to the relations of purchase and the other to the relations of sales in the economy. The two resulting matrixes have *m* x *n* dimensions, where *m* is the number of sectors in the economy and *n* the number of variables of solutions found in the decomposition of the original use matrix. The vectors that constitute these matrixes, therefore, match each of the n similarity variables found in the decomposition of the matrix to the different economic activities.

The number of variables found will be utilized to define the maximum number of clusters in the economy[13].

The resulting matrixes are submitted to a fuzzy cluster analysis and as a result produce membership matrixes, *m* x *c* dimensions, in which m represents the number of sectors in the economy and c is the number of clusters identified. These matrixes present the degree of relationship of each of the sectors of the economy to the clusters. The sum along the row that represents each sector of this matrix is one.

Based on the information of the membership matrix, we obtain the involvement matrix. This matrix has *m* x *c* dimensions, where m represents the number of sectors in the economy and c is the number of clusters, as in the original matrix. Contrary to the previous matrix, the values along each column add up to one, so that the degree to which an economic activity belongs to or is involved with a cluster can be measured in relation to the other economic activities belonging to the same cluster. According to Dridi & Hewings (2002a), this information is a more precise measurement to assess the relationship of economic activities in established clusters. Once the clusters have been identified, the subsethood between clusters is measured.

In this paper, the clusters were identified from the viewpoint of the inter-regional and isolated region system for 1999, and the national viewpoint, based on the national input-output matrixes of 1990 and 2002. The results are discussed in more detail below.

4.1 Inter-regional system

The decomposition of the inter-regional system utilized, composed of 186 economic activities, allows us to identify the maximum number of 91 clusters. Table 4 shows each of the clusters identified according to the purchase profiles, according to the activities that show the larger membership coefficient. These activities are called leader activities of the cluster. The

[13] The procedure is carried out using SPLUS software.

clusters are shown in the order in which they are identified by the method. Thus, the first cluster shown is led by the activity of Food products in the North.

In Table 5, we see the economic activities that lead the clusters, considering the sales profiles of the inter-regional system. This table can be read in the same way as Table 3. in this way, the first cluster identified according to the purchase profile of the inter-regional system is the cluster led by the Crops & Livestock activity in São Paulo.

The analyses according to the two viewpoints show the same leader activities for the clusters of the automotive industry. They highlight the region of São Paulo, where automotive activity (cars, spare parts and other vehicles) lead the different clusters. It is also worth mentioning that the commerce of spare parts and vehicles in São Paulo, seen in the automotive industry, also leads a cluster in the system. Other leader activities in the clusters are: trucks and buses in the rest of the South-east, cars, parts and other vehicles in the South, trucks and buses in the Central West, cars and parts and other vehicles in the North-east and trucks in the North.

Table 4. Clusters according to the purchase profiles in the inter-regional system, 1999

(ISPU = Industrial Services & Public Utilities)

Leader Activities		Leader Activities		Leader Activities
N - Food Products	31	NE - Plastics	61	SP - Public administration
N - Mineral extraction	32	NE - Clothing & footwear	62	SP - Clothing & Footwear
N - Commerce	33	NE - Various industries	63	S - Crops & Livestock
N - Non-metallic minerals	34	NE - Sale Vehicles/spare parts	64	SP - Various industries
SP - Man. Machinery & tractors	35	NE - Communications	65	SP - Sales of Vehicles & parts
N - Steelworks	36	SP - Crops & Livestock	66	SP - Communications
N - Electrical/Electronic Equipment	38	CO - Mineral extraction	67	SER - Food products
N - Trucks & buses	38	CO - Private services	68	SER - Private services
N - Wood & furnishing	39	CO - Non-metallic minerals	69	SER - Non-metallic minerals
N - Private services	40	CO - Steelworks	70	SER - Steelworks
N - Rubber industry	41	CO - Electrical/Electronic equip.	71	SER - Electrical/electronic equip.
N - Oil refinery	42	CO - Trucks & buses	72	SER - Trucks & buses
SP - Various chemicals	43	CO - Wood & furnishing	73	SER - Wood & furnishing
N - Pharmacy & veterinary	44	CO - Rubber industry	74	SER - Rubber industry
SP - Plastics	45	CO - Food products	75	SER - Oil refinery
N - Textile industry	46	CO - Oil refinery	76	SER - Pharmacy & veterinary
N - ISPU	47	CO - Pharmacy & veterinary	77	RSE - Textile industry
N - Transport	48	CO - Textile industry	78	SER - ISPU
NE - Crops & Livestock	49	S - Clothing & Footwear	79	SER - Transport
NE - Public administration	50	CO - ISPU	80	S - Public administration
NE - Ext. oil, gas, coal	51	CO - Commerce	81	S - Ext. oil, gas, coal
NE - Building	52	CO - Transport	82	S - Building
NE - Steelworks	53	RSE - Ext. minerals	83	S - Steelworks
NE - Man. Machinery/tractors	54	SP - Ext. oil, gas, coal	84	S - Man. Machinery/tractors
NE - Cars	55	SP - Building	85	S - Cars
NE - Parts & other vehicles	56	SP - Steelworks	86	S - Parts & other vehicles
NE - Cellulose, paper & printing	57	SP - Cars	87	S - Cellulose, paper & printing
NE - Chemical elements	58	SP - Parts & other vehicles	88	S - Chemical elements
RSE – Commerce	59	SP - Cellulose, paper & printing	89	S - Plastics
NE - Diverse chemicals	60	SP - Chemical elements	90	S - Diverse chemicals
			91	S - Various industries

Table 5. Clusters according to the sales profiles in the inter-regional system, 1999

	Leader Activities		Leader Activities		Leader Activities
1	SP – Crops & Livestock	31	NE - Plastics	61	SP – Sale vehicles/parts
2	N - Ext. mineral	32	NE - Clothing & Footwear	62	SP - Public administration
3	NE – Ext. oil, gas, coal	33	NE - Various industries	63	No activity
4	N - Non-metallic minerals	34	NE - Public administration	64	RSE – Mineral ext.
6	SP - Mach & tractors	35	NE – Sale vehicles/spare parts	65	RSE – Non-metallic minerals
5	N - Steelworks	36	No activity	66	RSE - Steelworks
7	N - Commerce	37	CO – Mineral ext.	67	RSE - Commerce
8	N - Electrical/electronic equip.	38	CO – Non-metallic minerals	68	RSE - Electrical/electronic equip.
9	N - Trucks & buses	39	CO – Steelworks	69	RSE - Trucks & buses
10	N - Wood & Furnishing	40	CO - Private services	70	RSE - Wood & Furnishing
11	N - Rubber industry	41	CO - Electrical/electronic equip.	71	RSE - Rubber industry
12	SP - Diverse chemicals	42	CO – Trucks & buses	72	RSE - Oil refinery
13	N - Oil refinery	43	CO - Wood & Furnishing	73	RSE - Pharmacy & Veterinary
14	N - Pharmacy & Veterinary	44	CO - Rubber industry	74	RSE - Textile industry
15	N - Textile industry	45	CO - Oil refinery	75	RSE - ISPU
16	N - Food products	46	CO - Pharmacy & Veterinary	76	RSE - Transport
17	N - ISPU	47	CO - Textile industry	77	RSE - Private services
18	N - Private Services	48	CO – ISPU	78	S - Crops & Livestock
19	N - Transport	49	CO – Commerce	79	S - Mach & tractors
20	NE – Crops & Livestock	50	CO – Transport	80	S - Ext. oil, gas, coal
21	SP - Plastics	51	SP - Ext. oil, gas, coal	81	S - Building
22	NE – Steelworks	52	SP - Building	82	S - Steelworks
23	NE - Mach & tractors	53	SP – Steelworks	83	S - Plastics
24	NE – Cars	54	SP – Cars	84	S - Cars
25	NE - Parts & other vehicles	55	SP - Parts & other vehicles	85	S - Parts & other vehicles
26	NE – Communications	56	SP - Cellulose, paper & printing	86	S - Cellulose, paper & printing
27	NE - Cellulose, paper & printing	57	SP - Chemical elements	87	S - Chemical elements
28	NE – Chemical elements	58	SP - Communications	88	S - Diverse chemicals
29	NE - Diverse chemicals	59	SP - Clothing & Footwear	89	S - Clothing & Footwear
30	NE - Building	60	SP - Various industries	90	S - Various industries
				91	S - Public administration

It is worth highlighting that the clusters identified according to the purchase profiles of the North, Central West and North-east regions (N – Trucks and buses, NE – Cars, and NE – Parts and other vehicles) are characterized as support activities of these very regions. In general, the clusters of São Paulo (SP – cars, SP – Parts and other vehicles and SP Commerce of vehicles and parts) in their turn are those belonging to the region of São Paulo, the South and the rest of the South-east and shown to be main support activities. The cluster of cars in the South shows the importance of the activities in that region and the rest of the South-east. The clusters with the highest degree of regional diversity in support activities are parts, in the South and trucks and buses in the rest of the South-east. When it comes to sales, the presence of support activities in the North, North-east and Central West in the clusters of the automotive industry is much more expressive, especially in the cluster led by the Commerce of vehicles and parts.

It is worth mentioning that the identification of a cluster in the. North, North-east and Central West must be assessed with caution since the method identifies clusters according to the similarity in inter-sector relations, not taking into account the value of the total production of the sector. In these regions, the results may indicate the potential for development of a cluster.

A fundamental aspect is that the productive relevance of the automotive industry in the rest of the South-east and São Paulo is not captured by the method when using the inter-regional system. In other words, the automotive industry of the rest of the South-east is not among the activities that present the highest values for the involvement of sectors in the automotive clusters in the North, North-east and Central West. This behavior is expected since involvement is a measure of the importance of sectors in the clusters. However, the method does not consider the value of the total production of the sector, but rather the input values.

In order to observe how clusters relate to one another, it is possible to assess their subsethood. The subsethood results in a matrix of c x c dimensions, where c represents the number of clusters identified in the economy. The main diagonal shows values equal to 1, expressing the maximum subsethood of the sector in relation to itself. The other cells in the matrix show values that vary from zero to one, equaling the mutual subsethood of clusters.

As suggested by Dridi & Hewings (2002b), the option was to consider the subsethood of those values that were above the average, i.e. over 0.5. Thus, seeking to observe the dependence between clusters in the whole inter-regional system, Figure 3 shows a matrix with these values estimated for the clusters according to the purchase profiles. In this graphic matrix, values above 0.5 appear highlighted in red, whereas those below average are in blue.

Note that in the main diagonal of this matrix, all the values are above average. In truth, the diagonal expresses the subsethood of a certain cluster with itself. Thus, the values found in the main diagonal will always be maximum, therefore equal to one. The clusters appear according to the order in which they were found in the cluster analysis. According to the Figure, for instance, it is possible to say that cluster 88 (led by activity S – Chemical elements) shows dependence on clusters 63 (S – Crops and livestock), 64 (SP – Various industries), 65 (SP – Commerce of vehicles and parts), 66 (SP – Communications), 67 (RSE – Food products), 68 (RSE - Private Services), 69 (RSE - Non-metallic minerals), 70 (RSE - Steelworks), and so forth.

When it comes to the automotive industry, the clusters led by the respective economic activities stand out: Cars (57), Parts and other vehicles (58) and Commerce of vehicles and parts (65) in São Paulo; and Cars (85) in the South, suggesting greater importance of these activities in the functioning of the economic system than those that do not show relevant subsethood.

We can also highlight the clusters in the economy led by transport activity in the North (18); Crops & Livestock (19), Public administration (20), Extraction of oil (21), Chemical elements (28), Diverse chemicals (30) and Communications (35) in the North-east (37), Steelworks (40), Commerce (51), Transport (52) in the Central West, Mineral extraction in the rest of the South-east (53); Cellulose & paper (59), Chemical elements (60), Public administration (61), Various industries (64), Communications (66) in São Paulo; Food products (67) Private services (68), Non-metallic minerals (69), Steelworks (70) & Transport (79) in the rest of the South-east; Crops & Livestock (63), Public administration (80), Cellulose & paper (87), Plastics (89) and Various industries (91) in the South.

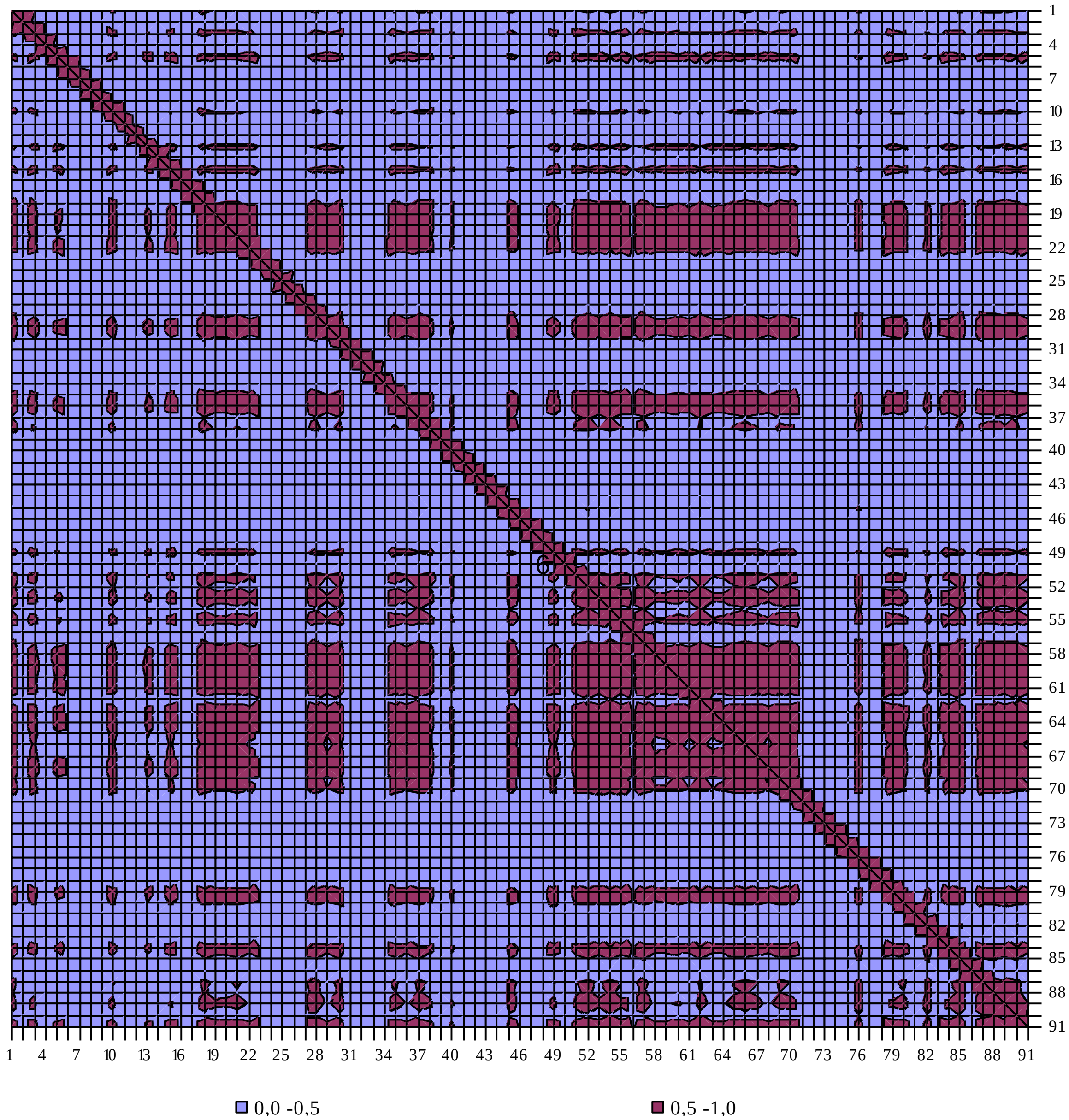

Figure 3 – Subsethood of clusters according to the inter-regional system purchase profiles - 1999

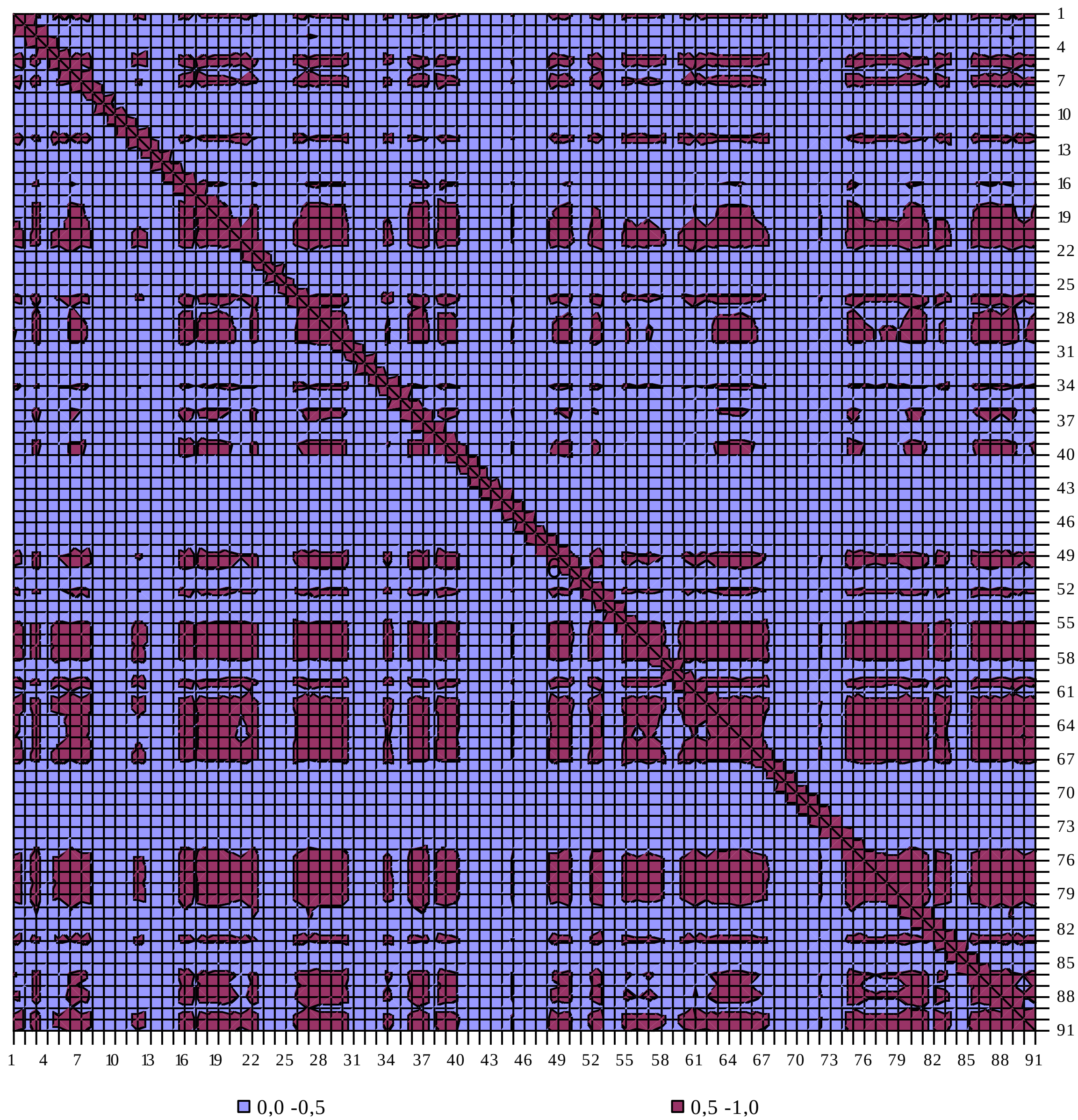

Figure 4 – Subsethood of clusters according to the inter-regional system sales profiles - 1999.

In Figure 4 we can see the dependence subsethood of clusters according to Sales profiles. The interpretation of this figure is similar to Figure 3. In general, this subsethood is much lower than the clusters according to purchase profiles. This behavior may be explained by the fact that many sectors that produce final goods, supply their products directly to final demand.

In the case of the automotive industry, only the clusters led by the activities of parts and other vehicles in São Paulo (55) and commerce of vehicles and parts (61) from São Paulo deserve to be highlighted.

Other clusters also stand out in terms of a dependence or relationship with the other above-average productive clusters. The following deserve to be highlighted: Public administration (34) in the North-east; Steelworks (39), Private services (40), Commerce (49) and transport (50) in the Central West; Building (52), Parts and other vehicles (55), Cellulose, paper & printing (56), Various industries (60) and Public administration (62) in São Paulo; Mineral extraction (64), Steelworks (66), Commerce (67), Transport (76) and private services in the rest of the South-east (77), Crops and livestock (78), Machinery & tractors (79), Plastics (83), Cellulose, paper & printing (86), Chemical elements (87), Diverse chemicals (88), Various industries (90) and Public administration (91) in the South.

4.2 **Clusters in isolated regions**

Evaluating regions in an isolated way and, therefore, not considering the inter-regional flows, the results are seen to be very similar from region to region. The clusters identified in relation to the sales profiles and purchase profiles were mostly the same in all the regions analyzed, as can be seen in Tables 6 and 7 respectively. These tables indicate the economic activities that led clusters in six regions. Thus, we see, for example, that the mineral extraction leads cluster in each of the regions.

Table 6. Clusters identified according to the purchase profiles of isolated regions

Economic Activities	North	North-east	Central West	São Paulo	Rest of the South-east	South
Mineral Ext.	X	X	X	X	X	X
Non-metallic minerals	X	X	X	X	X	X
Steelworks	X	X	X	X	X	X
Electrical/electronic equip.	X	X	X	X	X	X
Trucks & buses	X	X	X	X	X	X
Wood & furnishing	X	X	X	X	X	X
Rubber industry	X	X	X	X	X	X
Oil refinery	X	X	X	X	X	X
Pharmacy & veterinary	X	X	X	X	X	X
Textile industry	X	X	X	X	X	X
Food products	X	X	X	X	X	X
ISPU	X	X		X	X	X
Commerce	X		x	X	X	
Public administration	X		x	X	X	

Table 7. Clusters identified according to sales profiles in isolated regions

Economic Activities	North	North-east	Central West	São Paulo	Rest of the South-east	South
Ext. mineral	X	X	X	X	x	
Non-metallic minerals	X	X	X	X	x	X
Steelworks	X	X	X	X	x	X
Electrical/electronic equip.	X	X	X	X	x	X
Trucks & buses	X	X	X	X	x	X
Wood & furnishing	X	X	X	X	x	X
Rubber industry	X	X	X	X	x	X
Oil refinery	X		X	X	x	X
Pharmacy & veterinary	x	X	X	X	x	X
Textile industry	x	X	X	X	x	x
Food products	x	X	X	X	x	x
ISPU	x	X		X		x
Commerce						x
Public administration					x	

Considering the 31 sectors, 14 clusters were identified in each region; nevertheless, in some regions, there were clusters that were hardly defined. These clusters showed no economic activity in leadership; on the contrary, there were several economic activities with extremely low membership coefficients.

Even though the same economic activities led most of the clusters between regions, the dependence between clusters, not considering the flow between regions, is quite different. Following this logic for the analysis of clusters in the inter-regional system, Figures 5 and 6 show in red the subsethood between above-average clusters in the region.

In general lines, we see greater relationship between the clusters when it comes to purchase profiles. As mentioned beforehand, in the case of the inter-regional system, this accounts for why sectors that produce final goods supply their products directly to final demand. We also see that the clusters of the North-east, North and Central West regions are less dependent on each other in comparison to the other regions analyzed.

When it comes to the automotive industry, the only economic activity that appeared as a leader in a cluster is Trucks and Buses in all regions. This activity is represented in the following figures by clusters (7) in the North, North-east and Central West regions and São Paulo, (8) in the rest of the South-east and (6) in the South, according to the purchase profiles. As for the sales clusters, it leads clusters (7) in the North, (9) in the North-east, (8) in the Central West and the rest of the South-east and (6) in São Paulo and the South. In general, this activity shows a subsethood in relation to the other above-average clusters.

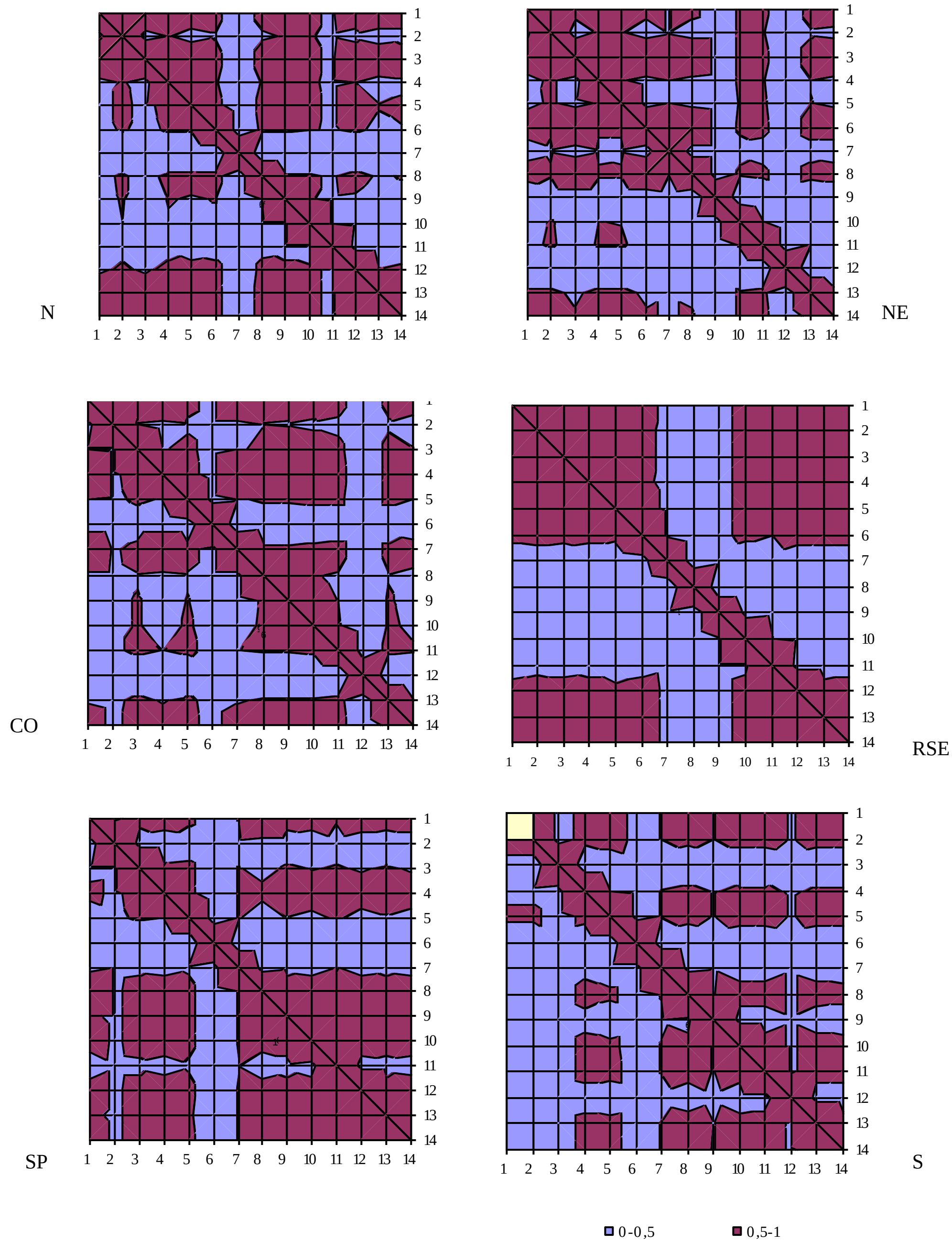

Figure 5 – Subsethood of clusters according to the sales profile of the regions

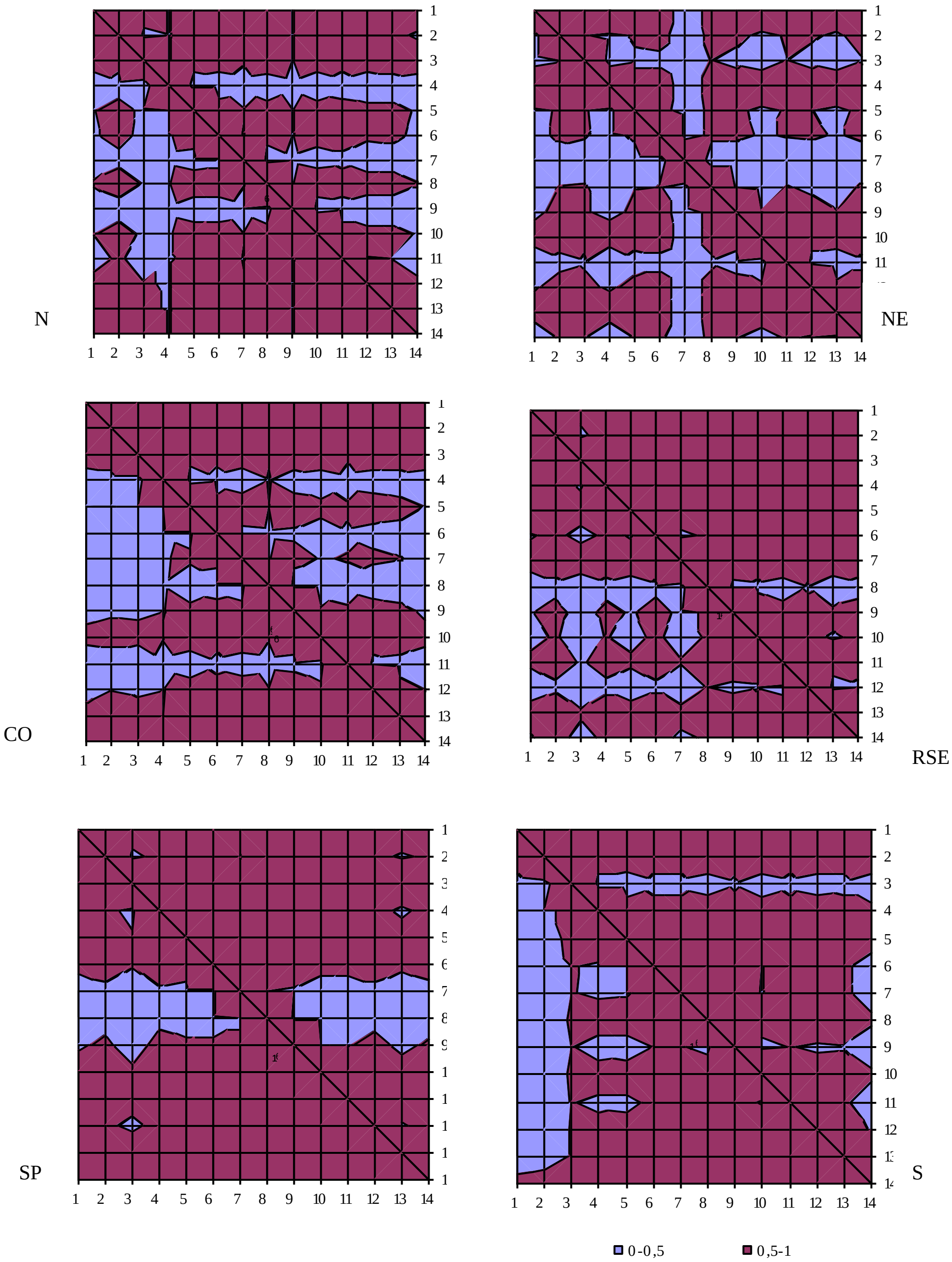

Figure 6 - Subsethood of clusters according to the purchase profiles of the regions

4.3 National Clusters

The identification method was applied to the matrixes of the Brazilian economy for 1990 and 2002. In Table 8, we can see the clusters identified according to the purchase profiles and according to the sales profiles for the two years. As for the automotive industry, the activity Other vehicles and parts stands out as it leads a cluster during both periods.

Table 8. Clusters identified in the Brazilian economy in 1990 and 2002.

	1990				2002		
	Purchases		Sales		Purchases		Sales
1	Public administration	1	Commerce	1	Commerce	1	Commerce
2	Mineral ext.	2	Mineral ext.	2	Mineral ext.	2	Mineral ext.
3	Non-metallic minerals	3	Public administration	3	Paper & Printing	3	Non-metallic minerals
4	Non-ferrous metallurgy	4	Non-metallic minerals	4	Non-metallic minerals	4	Non-ferrous metallurgy
5	Mach. & Tractors	5	Non-ferrous metallurgy	5	Non-ferrous metallurgy	5	Mach. & Tractors
6	Electronic equip.	6	Mach. & Tractors	6	Mach. & Tractors	6	Electronic equip.
7	Other vehicles & parts	7	Electronic equip.	7	Public administration	7	Other vehicles & parts
8	Commerce	8	Other vehicles & parts	8	Electronic equip.	8	Paper & Printing
9	Paper & Printing	9	Paper & Printing	9	Other vehicles & parts	9	Chemical elements
10	Chemical elements	10	Diverse chemicals	10	Chemical elements	10	Diverse chemicals
11	Diverse chemicals	11	Chemical elements	11	Diverse chemicals	11	Plastics
12	Plastics	12	Plastics	12	Plastics	12	Clothing
13	Clothing	13	Clothing	13	Clothing	13	Coffee industry
14	Coffee industry	14	Coffee industry	14	Coffee industry	14	Slaughter of animals
15	Slaughter of animals	15	Slaughter of animals	15	Slaughter of animals	15	Sugar industry
16	Sugar industry	16	Sugar industry	16	Sugar industry	16	Other food products
17	Other food products	17	Other food products	17	Other food products	17	ISPU
18	ISPU	18	ISPU	18	ISPU	18	Communications
19	Communications	19	Communications	19	Communications	19	Public administration

The subsethood of clusters identified in both years can be seen in Figure 7. Comparing the two periods, we see that the productive structure in 2002 shows clusters with greater subsethood. This pattern is observed in both the purchase and sales profiles of the economy. A possible explanation for this behavior may be the opening of the economy in the nineties. With the increase of imports, domestic economic relationships became less dense since imported input utilized in some industries had prices and/or quality that was superior to their domestic equivalents.

purchase

sales

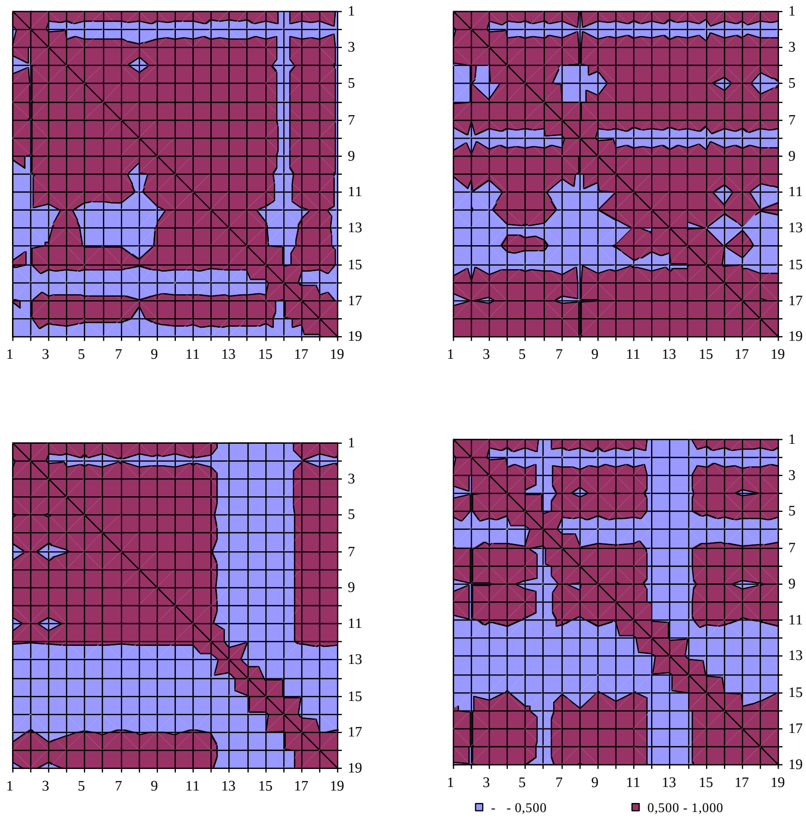

Figure 7 – Subsethood of clusters in 1990 & 2002

It is worth remembering that the methodology applied is still preliminary, proposed by Dridi & Hewings (2002a & 2002b) and applied by the authors in the analysis of the use matrixes of the economy of the United States. There have been no applications by other authors aiming to analyze the flow of input in the Brazilian economy. Simões (2003) applied the method and obtained interesting results.

5 CONCLUSIONS

The aim of this paper has been to carry out an analysis on the importance of the Brazilian automotive industry through the analysis of fuzzy clusters. Studies of this nature, especially those dealing with the Brazilian economy, face difficulties and limitations owing to the utilization of input-output matrixes and estimated inter-regional systems.

In the case of national matrixes, the latest official data made public by the IBGE (Brazilian Institute of Geography and Statistics), used in this paper, were from 1996. Therefore, it was necessary to estimate the matrixes for 1996 to 2002 using information from the National System of Accounting as a basis for these years. The information about the inter-regional system was obtained from set of data that comprises several research projects.

Even with all the criteria utilized to obtain the information on the flow of Brazilian input-output matrixes, such as methods of consistency between regional and national systems, the data could still be refined. However, it is necessary to emphasize that possible improvements depend above all on the availability and precision of information at regional and sector levels from complementary data bases. At the moment, even with the advances in the research of the IBGE and some sector institutions, the difficulty to obtain more detailed information on the North, North-east and Central West regions of Brazil and some sectors, especially those informally involved in the economy, still remains.

The methodology of analysis used here has some advantages over traditional cluster analysis methods that identify crisp clusters, which generally require arbitrariness on the part of the researcher and do not consider the fact that a sector may be present in more than one cluster of the economy. In the fuzzy approach, the groupings do not exclude all economic activities belonging to the groupings. The need for methodological sophistication is more evident in the analysis of clusters in the inter-regional system. This is because the data does not clearly indicate the relevance of the activities of São Paulo and the rest of the Southeast in the clusters of the other regions. An interesting alternative to perfect the analysis, may be to study the possibility of considering the value of production in the pondering of the data submitted to cluster analysis.

The method, in its turn, provided interesting results in the analysis of the national productive structure. The analyses show that with the opening of the economy and the consequent entry of imported products into the Brazilian economy in the nineties, the national clusters showed less dependence on each other, reflecting the lower dynamism in the productive relationships of the national economy. In other words, the results suggest that with the opening of the economy to international commerce, the productive relationships between domestic clusters became more fragile.

This paper has contributed to applying an analysis methodology that has been little used and explored in studies that make use of the input-output theory. To this end, the difficulties and limitations found in the application of the method can be seen as stimuli do developing future studies.

REFERENCES

ASSOCIAÇÃO NACIONAL DE VEÍCULOS AUTOMOTORES (2004). **Anuário da indústria automobilística brasileira 2003**. http://www.anfavea.com.br (10 abr. 2004)

ASSOCIAÇÃO NACIONAL DE VEÍCULOS AUTOMOTORES (2004). **Anuário da indústria automobilística brasileira 2004**. http://www.anfavea.com.br (07 ago. 2004)

AUTOMOTIVEBUSINESS (2004). **O mapa da produção**. http://www.automotivebusiness.com (12 jul. 2004)

ARBIX, G.; RODRIGUEZ-POSE, A. (2001). Strategies of waste: bidding wars in the brazilian automomotive sector, **International Journal of Urban and Regional Research**, v.25, n.1, pp.134-154.

BAER, W. (1995) **Economia brasileira**. São Paulo: Nobel.

BEDÊ, M.A. (1997) A política automotiva nos anos 90, in: ARBIX, G.; ZILBOVICIUS, M. (Org.). **De JK a FHC**: a reinvenção dos carros. São Paulo: Scritta.

BERGSMAN, J.; GREENSTON, P.; HEALY, R. (1972) The agglomeration process in urban growth. **Urban Studies**, v.9, n.3, pp. 263-288.

BERGSMAN, J.; GREENSTON, P.; HEALY, R. (1975) A classification of economic activities based on location patterns, **Journal of Urban Economics**, v.2, n.1, pp.1-28.

BLIN, J.M.; COHEN, C. (1977) Technological similarity and aggregation in input-output systems: a cluster-analytic approach. **Review of Economic Statistics**, v.59, n.1, pp.82-91.

BONELLI, R. (2001) **Políticas de competitividade industrial no Brasil**: 1995/2000. 44pp. Brasília: IPEA (Texto para discussão, 810)

BONELLI, R.; VEIGA, P.M. (2003) Dinâmica das políticas setoriais no Brasil na década de 1990: continuidade e mudança. **Revista Brasileira de Comércio Exterior**, n.75, pp.1-24.

CAVALCANTE, L.C.; UDERMAN, S. (2002) **The cost of a structural change**: a large automobile plant in a brazilian less developed region. Urbana: University of Illinois, Regional Economics Applications Laboratory. (Discussion paper, 04-T-5).

CECCHINI, K. Setor automotivo brasileiro: evolução da estrutura produtiva e sua importância regional nos anos 90. Piracicaba, 2005. Dissertação (Mestrado) – Escola Superior de agricultura " Luiz de Queiroz", Universidade de São Paulo.

CZAMANSKI, S.; ABLAS, L.A.Q. (1979) Identification of industrial clusters and complexes: a comparison of methods and findings, **Urban Studies**, v.16, pp.61-80.

CZAMANSKI, S. (1974) **Study of clustering of industries**. Halifax: Dalhouse University, Institute of Public Affairs.

DRIDI, C.; HEWINGS, G.J.D. (2002a) **Toward a quantitative analysis of industrial clusters I**: fuzzy clusters vs crisp cluster. Urbana: University of Illinois, Regional Economics Applications Laboratory. (Discussion paper, 02-T-1)

DRIDI, C.; HEWINGS, G.J.D. (2002b) **Toward a quantitative analysis of industrial clusters II**: shapley value, entropy, and other fuzzy measures. Urbana: University of Illinois, Regional Economics Applications Laboratory. (Discussion paper, 02-T-6)

FEIJÓ, C.A.; RAMOS, R.L.O.; YOUNG, C.E.F.; LIMA, F.C.G.C.; GALVÃO, O.J.A. (2001) **Contabilidade social**: o novo sistema de contas nacionais do Brasil. Rio de Janeiro: Editora Campus.

FERRO, J.R. (1992) A produção enxuta no Brasil, in: WOMACK, J.P.; JONES, D.T.; ROSS, D. et al. **A máquina que mudou o mundo**. pp.311-337. Rio de Janeiro: Campus.

HEWINGS, G.J.; SCHINDLER, G.R; ISRAILEVICH, P.R; SONIS, M. (1998) Agglomeration, clustering, and structural change: interpreting changes in the Chicago regional economy, in: STEINER, M. (Ed.). **Clusters and regional specialization**. Heidelberg: Springer Verlag.

HOEN, A.R. (2002) Identyfing linkages with cluster based methodology. **Economic Systems Research**, v.14, n.2, pp.131-146.

HUMPHREY, J.; LECLER, Y.; SALERNO, M. (Ed) (2000) **Global strategies and local realities**: the auto industry in emerging markets. New York: St. Martins Press.

KAUFMAN, L.; ROSSEEUW, P.J. (1990) **Finding groups in data**: an introduction to cluster analysis. New York: Wiley

LAPLANE, M.F.; SARTI, F. (1997) The restructuring of brazilian automobile industry in the nineties. **Actes du GERPISA**, n.20, pp.31-48.

LEONTIEF, W. (1986) **Input-output economics**. 2.ed. New York: Oxford University Press.

MILLER, R.E.; BLAIR, P.D. (1985) **Input-output analysis**: foundations and extensions. New Jersey: Englewood Cliffs.

NISHISATO, S. (1994) **Elements of dual scaling**: an introduction to practical data analysis. New Jersey: Lawrence Erlbaum Associates.

OOSTERHAVEN, J.; EDING, G.J.; STELDER, D. (1999) Clusters, forward and backward linkages, and bi-regional spillovers: policy implications for the two dutch mainport regions and the rural north (compact disc). In: EUROPEAN CONGRESS OF THE REGIONAL SCIENCE ASSOCIATION, 39., Dublin **Proceedings**. Dublin: Carfax.

ORENSTEIN, L.; SOCHACZEWSKI, A.C. (1999) Democracia com desenvolvimento, in: ABREU, M. (Org.). **A ordem do progresso**: cem anos de política econômica 1889-1989. 10.ed. Rio de Janeiro: Campus.

PIANCASTELLI, M.; PEROBELLI, F. (1996) **ICMS**: evolução recente e guerra fiscal. Brasília: IPEA. (Texto para Discussão, 402)

ROEPKE, H.; ADAMS, D.; WISEMAN, R. (1974) A new approach to the identification of industrial complexes using input-output data. **Journal of Regional Science**, v.14, pp.15-29.

SANTOS, A.M.M.M.; BURITY, P. (2002) Complexo automotivo, in: BANCO NACIONAL DE DESENVOLVIMENTO ECONÔMICO E SOCIAL. **BNDES 50 anos**: histórias setoriais. Rio de Janeiro.

SANTOS, A.M.M.M.; PINHÃO, C.M.A. (1990) Pólos automotivos brasileiros. **BNDES Setorial**, n.10, set. 1999, pp.173-200

SIMÕES, R.F. (2003) **Complexos industriais no espaço**: uma análise de *fuzzy cluster*. Belo Horizonte: Universidade Federal de Minas Gerais (UFMG)/Cedeplar. (Texto para discussão, 209)

STREIT, M.E. (1969) Spatial association and economics linkages between industries. **Journal of Regional Science**, v.9, p.177-188.